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Teachers as Stakeholders in Mathematics Education Research

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Abstract: *In this paper, we report on our experiences with professional development at the Calgary Girls School in Alberta, Canada. In particular we reflect on factors such as mentoring and teacher coaching that contribute to higher student achievement as well as a culture of co-operation and collaboration in the context of the Alberta Initiative for School Improvement (AISI).*

Keywords: Mathematics teacher professional development; Calgary Girls School; Alberta Initiative for School Improvement; mentoring; teacher coaches; Galileo Educational Network Association

Background Information on the Calgary Girls School

The Calgary Girls' School is a public charter-school in Calgary, Alberta, Canada that was founded in 2003. The school consists of 600+ students in Grades 4-9 across two campuses who come from a wide range of socio-economic, religious, and academic backgrounds. The school places great emphasis on the extensive use of collaboration as a strategy between and among parents, girls and staff. The collaborative culture that has been established over numerous years at the Calgary Girls' School is based largely on the work of DuFour (2005) and the creation of Professional Learning Communities.

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The Calgary Girls' School seeks to enhance girls' confidence in their abilities, particularly in the areas of mathematics, science, and technology. The mathematics program at the Calgary Girls' School places value on depth rather than breadth, the justification of solutions obtained using multiple problem-solving approaches, the use of concrete materials and pictorial solutions as a means of conveying understanding, collaborative learning amongst students, and the identification and exploration of the authentic applications of mathematics. Teachers of students entering the Calgary Girls' School spend much time revising students' perception that they are lacking the ability to do mathematics. The structure, focus, and intent of the math program at the Calgary Girls' School owes much to the influence of Hanson (1992), Pettitt (1995), Gutbezahl (1995), and others. Moreover, teachers at the school are very familiar with the work of John Van de Walle, and have developed their teaching practice in the area of mathematics thanks in large part to his influential teacher resource, "Elementary and Middle School Mathematics".

Introduction

What follows is a written reflection from the perspective of two mathematics teachers who in December 2011 completed a four-day workshop focused on the professional development of in-service mathematics teachers at all grade-levels, excluding post-secondary education. Over the course of these four days, a number of mathematics education researchers, professional development facilitators, and professional mathematicians spoke about their successes and struggles in implementing professional development with mathematics teachers in their respective countries. In hearing from the various presenters, a number of thoughts came to mind regarding the various types of teacher professional development that we, as teachers, have received thus far in our professional teaching careers.

In this paper, we address several key points: 1) the importance of relationship between PD facilitators and teaching staff to the success of professional development initiatives, 2) the manner in which a collaborative professional learning community built on trust allows for teachers to take risks necessary for significant professional growth to take place, 3) the importance of accessing teacher input when determining possible directions for professional development, and 4) our experience with a province-wide professional development initiative known as the Alberta Initiative for School Improvement. We also discuss the importance of the presence of a teacher coach on our teaching staff, as well as the significant influence that an individual in this role can have on the growth and professional development of new teachers.

The importance of relationship

Teaching is highly personal work. The various lessons and units of study created by teachers consist of the teacher's own thoughtful ideas and creative approaches to taking up curriculum. By consequence, there is a tendency for teachers to take criticism of their work from those outside of the school quite personally, perhaps even shutting down when such criticism comes across as too harsh. We would differentiate criticism from critique, the former considered to be feedback provided by those without a strong personal stake in the learning of the students and the latter being feedback focused more specifically on instruction than the teacher themselves. It is our belief that by first addressing what is strong in a teacher's work, whatever that may be, there is a greater likelihood that teachers will develop a trusting relationship with those they are working with and be open to the ideas being shared with them.

It is our belief that relationship is first and foremost to being a good teacher. If there is not a relationship present between teacher and student, then learning is less likely to occur.

Students, both young and old, need to feel safe in their learning surroundings and believe that their teacher is fully invested in knowing each individual they will be working with; this includes understanding where the student is coming from, what they know, what they want to know, and what they do not know.

In order to cultivate a collaborative and supportive environment, it is essential to build relationships between teachers and math educators. The deepest learning in the classroom often exists when the teacher-student relationship is a focus and the same can be said for the teacher-PD facilitator relationship. Listening to the teachers' perspective in order to truly understand where the teacher is starting from and to build on the strengths of the individual are critical to the success of this relationship. It is also important for the teacher to know and understand the underlying goals and theories behind any PD educator's approaches.

Culture of Collaboration and Trust

Upon starting a career at the Calgary Girls' School one of the important draws is the administration's recognition that every teacher, regardless of the number of years of experience they bring with them, is in a place of learning. In fact, the administration team at the Calgary Girls' School makes it clear to new graduates of teacher-education programs that their first year at the school could be viewed instead as their 3rd year of their 2 year education program. There is an implicit understanding that the attainment of perfection in one's teaching practice is not expected nor is it reasonable to anticipate. The administration wants all teachers, regardless of years of experience in the classroom, to always ask questions and engage in dialogue with co-workers. Teaching at the Calgary Girls' School does not exist in a closed room in isolation. Instead, teachers are grouped in grade teams supported by specialist teachers, support staff, and

administration. There isn't a day that goes by when there is not a conversation in the hallway or in a team meeting about curriculum, various tasks or individual student needs. At the Calgary Girls' School, teachers have a collective goal as a group, and that goal is to educate students to the absolute best of the teaching staff's collective abilities.

In order for professional development initiatives to take hold, our view is that teachers must belong to a collaborative working environment where support is provided from colleagues and administrative staff alike. The process of altering one's teaching practice takes time and can certainly place a teacher in a challenging professional space. To change one's teaching practice also requires support from colleagues and open communication about the struggles one is experiencing in implementing the specific teaching practices shared with teachers through professional development work. A culture of collaboration and openness allows teachers to share their concerns with one another and uncover what is and isn't working, then initiate the types of solutions recommended through professional development projects.

There is a culture of collaboration present throughout the Calgary Girls' School. When potential teachers interview for teaching vacancies at the school, they are told outright about the expectation placed on teachers to collaborate. Teachers are required to meet on a weekly basis with the other members of their teaching team to plan collaboratively in creating interdisciplinary inquiries. Collaboration is an expectation of not only the administration, but the teaching staff, as well. Teachers at the Calgary Girls' School hold one another accountable. If a fellow colleague brings forth an idea, teachers work as a team to bring the idea to an even higher level. Teachers discuss the relevance of the task, the formative/summative assessment, the underlying reason behind pursuing such a task, the ways in which teachers will fully engage (hook) the students into the topic or inquiry being pursued. By consistently asking themselves,

what is worth knowing, why should students care about a topic?, and why people fall in love with a given topic, teachers at the Calgary Girls' School do much to create engaging projects and inquiries through collaborative work and dialogue with colleagues.

Example #1: Teachers Seeking Subject-Specific Support from Colleagues

Teachers at the Calgary Girls' School come into the teaching profession with a wide-range of undergraduate experience, completed prior to pursuing degrees in education. As such, there are teachers on staff with a wide-range of basic expertise in fields ranging from Fine Arts, Entomology, Political Science, Earth Science, to Biology, and so on. Teachers on staff at the Calgary Girls' School are made aware of the range of expertise accessible within their own ranks and are encouraged to both pursue and lend such expertise when in need.

At the Calgary Girls' School, it is not uncommon for teachers of a particular subject or grade to seek assistance from another staff member who possesses sought-after expertise. For example, one year, a Grade 9 mathematics teacher was hoping to explore the concepts of congruence and similarity of polygons with his students by having them create some geometric art-work. While this teacher felt confident with the mathematics behind this work, they felt much less confident in choosing a medium for the work or understanding what would be required of one who chooses to create a geometric piece of art. This teacher knew that one his colleagues in Grade 8 had a background in Fine Arts, and so, dropped by their classroom to request assistance. The Grade 8 teacher proceeded to compile a list of images of various geometric abstractions she had studied and even re-created in her undergraduate studies, which she then forwarded over to the mathematics teacher, along with some suggestions for a possible medium to work with and techniques to apply with this project.

This sort of experience is commonplace at the Calgary Girls' School and occurs both within and across grade-teams. If teachers are pursuing a larger-scale project, time is afforded to them by the administration to exit their classrooms and join other teaching teams with the intent of lending their particular expertise.

Example #2: Teachers Seeking Support Regarding Teaching and Learning from Colleagues

At the Calgary Girls' School, teachers not only lend the expertise they garnered during the completion of their undergraduate degrees, but also the teaching expertise they acquired from their previous years teaching. The vast majority of teachers at the Calgary Girls' School have experience teaching several grades, which is a result of the administration's policy of switching teachers from grade-to-grade. By consequence, teachers can lend the expertise they gained from teaching a previous grade to the current teachers of that grade.

For example, during our cycle III AISI project regarding hands-on science, the two Grade 9 mathematics/science teachers were granted their request to spend a day working with both a former Grade 9 teacher and a Grade 5 teacher, both of whom possessed a wealth of knowledge on the concepts from the Grade 9 Electrical Principles unit. These four staff members were granted one full day to congregate in the school science lab to play with and create series and parallel circuits, motors, generators, fuses, and lemon cells, etc. On this day, the teachers with previous experience teaching electrical principles shared all that they knew with their less-experienced colleagues, who also had the time to explore the concepts to be uncovered in this unit and overcome the anxiety they had been feeling in preparing to teach this challenging science unit. The Grade 9 teachers who took part in this in-house professional development day

not only left with a greater sense of confidence in their ability to teach this unit, but also a vast array of possible lessons and activities to implement in their classrooms in the coming weeks.

Example #3: Vertical Planning and Collaboration

Vertical planning has proved to be an excellent space for collaboration and professional development within our school. One concrete example of this experience is focused around the exploration of the Cartesian plane. A need arose out of a grade four classroom to utilize graphing as a tool to make sense of a set of collected data. In order to pursue this concept, the grade four teachers decided to ride the wave of energy generated by the students and stop their current exploration of patterns in order to investigate graphing. Through discussion and conversation with our “teacher coach” and a fellow colleague who taught grade nine it became evident the exploration in the grade four classroom was essential for the development of knowledge in the grade nine classroom. What was realized, through discussion and access to a teacher coach who was joining the discussion within each grade team, was there was a gap in our students’ learning surrounding the plotting of co-ordinate points on a Cartesian plane. The recognition of this gap informed the grade four teaching teams’ planning and exploration of the concept of graphing. “Why do we use graphs?”, “what are graphs?”, “how do we graph data?”, and “what story will graphed data tell?” were just a few questions the teachers began to explore with their grade four students. In order to effectively graph their collected data, the students needed to develop the skills of plotting co-ordinates on a grid. Concurrently the grade nine classes were exploring tessellations and translations of shapes on a co-ordinate grid. The constant dialogue between the teacher coach and the teachers of each respective grade, allowed for authentic and rich exploration of a concept and idea across the grades.

Example #4: The Sharing of Planning Documents Amongst Staff

It would not be uncommon to see a teacher at CGS notice a great rubric or activity on the photocopier and grab a copy for themselves. The culture of sharing our work with colleagues is pervasive throughout the school. In fact our school has adopted the use of Intelligence On-line (IO) as our whole school planning tool. Created by the Galileo Educational Network Intelligence On-Line is a web-based professional learning environment created to provide support to teachers in their planning.

“The foundation of IO is an inquiry-based approach that opens doors to powerful learning opportunities. Inquiry begins with a meaningful problem, issue or topic. Students build new knowledge as they work through intriguing tasks. They solve problems, uncover issues and rigorously test their discoveries and they learn to use technology to think in new ways.” (Intelligence On-Line).

Utilizing this on-line tool teachers share each of the projects designed by their teams with one another. While a particular person might start the project and have it listed under their name, these projects are not owned by any one individual. As we do not work in isolation, none of our tasks or activities exist solely because of one teachers voice. Whether we have just switched the grade we teach and are uncovering curriculum for the first time, or we are exploring the same concept across the grades such as the Cartesian plane, asking for support or resources from our fellow colleagues is not only supported it is expected. In addition to the on-line planning tool which supports teachers in the design process of a rich and rigorous inquiry, IO also provides

space for discussion with colleagues and experts regarding the topics of exploration, thereby extending the circle of collaboration beyond the walls of the school.

“The IO community is made up of thousands of professional educators designing great projects. Anytime you run into a roadblock, you can communicate with your own personal network of IO members; or collaborate with the community to share, give input or receive feedback.” (Intelligence On-Line)

Teacher Voice in the development of PD

We believe that the form of professional development that is most fully embraced by a teaching staff appears to come about in response to the needs of teachers; needs identified by teachers and communicated to their administrators. Teachers view themselves as professionals capable of assessing the learning of their students and creating engaging activities that do well to develop students' understanding of relevant learning objectives. While they may not formally engage in the process of educational research, teachers do make observations of learners and learning on a daily basis. As such, teachers have much to contribute to the conversation around teaching and learning, and are eager to share their thoughts on these topics. It is our belief that teachers are less likely to pursue professional development initiatives that have been created for them in response to a need identified by administrators or a resource from outside the school. Teachers need not necessarily be consulted regarding the forms of professional development they would like to pursue, but would appear to be more likely to pursue professional development initiatives when such consultation takes place or when such initiatives are teacher-driven.

Alberta Initiative for School Improvement

At the Calgary Girls' School, teachers have taken part in numerous professional development activities that met this standard. The Calgary Girls' School has taken part in the past three cycles of the Alberta Initiative for School Improvement or AISI. AISI provides funds to schools to develop and pursue professional development plans intended to foster student engagement and advance teachers' professional practice (Alberta Education, 1999). Our school had the fortunate experience of benefiting from AISI projects. With each cycle of the project lasting 3 years, CGS has been involved in 3 full cycles, each with a different focus.

The first cycle of AISI at the Calgary Girls' School (AISI cycle II) focused on developing teachers' abilities as mathematics educators in a middle school setting. This was one example of a sustained long-term professional development opportunity that was continually evaluated throughout the 3 year duration of the project. As teachers who entered the school in both the final year and the first year after the "Math AISI project" the learning and engagement regarding the teaching of mathematics was still incredibly evident to us. As new teachers we were brought into the dialogue and discussion regarding math education even after the project was complete, through one-on-one sessions with administration, teacher-led examples of what problem-centered math education could look like in the classroom, provided supporting resources (specifically, Elementary and Middle School Mathematics by Van de Walle), and on-going dialogue. As new teachers we felt as if the first AISI cycle at the Calgary Girls' School was alive in the classroom and among teachers regardless of whether it was still a school wide focus.

The second cycle (AISI cycle III) focused on developing teachers' abilities to teach science with a hands-on approach. Specifically, the project description read: "Engage students

through inquiry-based learning, scientific experimentation, hands-on activities and projects and provide teacher professional development through the use of coaching experts, research and assessment for learning.”

Our “Hands-on Science” AISI project is an excellent example of PD that was sustained, consistent and revisited throughout the three years of the project. This particular project came from a recommendation by Alberta Education following an evaluation of our school. Science teaching and learning was identified as an area of growth for our school. This recommendation was brought forth to the teaching staff by the administration, however instead of telling us that this was our next goal and outlining exactly what our PD was going to look like, the administration invited dialogue and discussion surrounding our new goal. The fact that as teachers we were invited into the creation of our science AISI goal, helped us feel as though we had ownership and a voice in the project, thereby supporting our own engagement in the learning.

Our project purpose: To improve achievement, understanding of Science concepts and interest in scientific inquiry for girls in grades 4-9.

Improvement Goals:

1. To improve girls’ learning and achievement in Science
2. To improve student achievement in Science through building teacher capacity in the teaching of Science.

As teachers we were provided any resources we deemed necessary to propel our work in science to the next level. The professional development opportunities included but were not

limited to:

- professional development days with science experts where teachers were provided with several hands-on challenges and guided through them with the assistance of these experts, -days spent planning and “playing” with concrete materials with the assistance of other members of the teaching staff who had experience teaching concepts at hand,
- time spent at science professional development sessions offered by local science teachers through the Calgary Science Network.

Coined “AISI” days, time in grade teams or discipline teams provided to teachers played a significant role in our ability to benefit from the project. Being given “time to play” with the idea, concept or material provided space for teachers to truly engage in the discipline, to enter the terrain we want students to enter. As teachers we become the learner and therefore find ourselves in a position where we can understand the perspective of the student and thereby deconstruct the experience, thereby preparing us to engage with the students in meaningful and authentic ways.

At the outset of our second cycle AISI project, the administration of our school invited several experts in science education to come and work with our staff. In year one of AISI cycle III, each teaching team met with Dr. Sharon Friesen, a faculty member at the University of Calgary with a lengthy background as both an educator and teacher educator.

During these meetings, Dr. Friesen assisted teachers in each team in creating engaging, rigorous, and hands-on activities to be pursued with students in the team’s respective grades. Dr. Friesen played a significant role in developing our teaching staff’s confidence in their ability to teach science with a hands-on approach, due in part to her vast knowledge-base and creative approach to teaching.

Perhaps more important than Dr. Friesen's expertise in the area of science education, however, was her unique ability in creating open, trusting, and constructive relationships with the teachers she works with. Dr. Friesen begins each session with a given teaching team by first listening to their plans then acknowledging the strengths in the work being shared. Dr. Friesen is particularly skilled in implementing professional development due to both her willingness to investigate the history of the school and teachers she is working with, as well as her view that professional development should be focused on building on strengths, rather than remedying weaknesses.

As teachers working with Dr. Friesen, it was evident to us that she viewed teachers as playing a pivotal part in their professional development pursuits. From working with Dr. Friesen, it became apparent to us that she values teachers' ideas and unique qualities, and makes every effort to incorporate, rather than mute, their voices. Dr. Friesen's ability to create and foster relationships with the teachers she works with has made her a very welcome member in our school community and a trusted voice who can be turned to when teachers find themselves in need of assistance.

We could also argue that our work in hands-on science learning, also supported our work in mathematics as many of the skills developed regarding student engagement were definitely transferable. As teachers, simply reflecting on our own comfort level as a science teacher provided ample evidence to suggest that this project was very effective. In order to further evaluate our progress, admin provided teaching staff, parents, and students with questionnaires intended to gauge the confidence teachers had in teaching science, as well as student perceptions of their abilities as scientists proceeding each year of the project. There was notable increase in

students' confidence in their abilities as scientists, notable increase in teachers' confidence in their abilities as science teachers. As well there were significant increases in student performance at the Grade 6 and Grade 9 levels on provincial achievement tests, particularly regarding the percentage of students who met the standard of excellence on these standardized tests.

Qualitative Results following the 3 year cycle: 2008/2009 School Year

Teacher Measures:

2008/2009 Results:

- 100% of CGS teachers are strongly confident in teaching science from an inquiry-based approach
- 97% of CGS teachers report that they are very confident in their knowledge and understanding of interpreting the science curriculum into rich hands on science experiences
- 97% of CGS teachers report that they are confident in their ability to create strong assessment tools in science

Teacher Comments:

"AISI funding has allowed the school to obtain resources that have improved my teaching. In addition, we have the time to plan within our teams to design rich hands-on learning experiences for our students."

"This past year has really supported my ability to teach Science. I learned that I had to take the time to play and be a scientist myself in order to generate excitement within students."

Student Measures:

2008-2009

- 80% of CGS students think of themselves as scientists
- More than 90% of CGS students see themselves contributing to new knowledge in science using an inquiry approach

Student Comments:

"I enjoy the fact that we try hand on experiments instead of only using books to find out what we need to know. We get to be the scientists and try everything for ourselves."

"The part of science that I enjoy the most would be the hands-on work and experiments that we get to do. I enjoy being able to see all of the scientific theories in action. When I experiment with science hands-on, it gives me a greater understanding of the topic."

Parent Measures:

2008-2009

- 81.9% of parents report that their daughter has demonstrated increased understanding in science
- 74.1% of parents see their daughter improving in science
- 73.6% report that their daughters interest in science has increased

PAT Results: Over 2 years of the cycle**Grade 6 2007-2008**

Measure (from project plan)	Baseline	Target	Actual
% of students meeting the acceptable standard in grade 6 Science.	94	97	94.8
% of students meeting the standard of excellence in grade 6 Science.	21	27	28.7

Grade 6 2008-2009

Measure (from project plan)	Baseline	Target	Actual
% of students meeting the acceptable standard in grade 6 Science.	94	97	98.9
% of students meeting the standard of excellence in grade 6 Science.	21	27	36.6

Grade 9 2007-2008

Measure (from project plan)	Baseline	Target	Actual
% of students meeting the acceptable standard in grade 9 Science.	86	92	89.9
% of students meeting the standard of excellence in grade 9 Science.	14	21	24.7

Grade 9 2008-2009

Measure (from project plan)	Baseline	Target	Actual
% of students meeting the acceptable standard in grade 9 Science.	86	92	98.8
% of students meeting the standard of excellence in grade 9 Science.	14	21	52.5

Teacher Coach:

It is our contention that teachers, especially those in their beginning years, would benefit a great deal from having access to an in-house teacher coach or mentor. Too often, teachers are thrust into their profession with little formal support in place. By modeling lessons for teachers and providing them with feedback on their work, as well as suggestions for how to successfully differentiate instruction, mentors could certainly provide novice teachers with much-needed professional support.

For much of its existence, the Calgary Girls' School employed a part-time teacher coach and mentor. This teacher coach was a classroom teacher with 10+ years of experience teaching various core subjects, as well as fine arts, to many different grade levels. The teacher coach's primary responsibility consisted of making scheduled visits to the classrooms of novice teachers to observe their teaching. The teacher coach also met with novice teachers during their prep times to share feedback from the observations they had made, share strategies for differentiating instruction, discuss the process of report-card writing, and assist with the preparation of engaging learning activities in each subject area.

The teacher coach also did much to develop novice teachers' emerging understanding of concepts they were required to teach. One novice teacher who was struggling with the challenging concepts of trigonometry scheduled a meeting with the teacher coach to discuss and develop their comprehension of this difficult concept. At the outset of this meeting, the novice teacher discussed the confidence they had in applying a procedural understanding of trigonometry in order to successfully solve problems, while at the same time acknowledging their lack of a sufficient understanding of sine, cosine, and tangent ratios. The novice teacher had

no idea why $\tan 45 = 1$, but wanted to know in order to both satisfy their own curiosity as a learner and to better serve the students they were going to be teaching in the coming weeks. The teacher coach, who had previously taught the concept of trigonometry to her own class of Grade 9 students, began to draw a series of different-sized right-angle triangles with legs of equivalent length and explain why the concept of the tangent as a ratio of the opposite and adjacent sides in a right-angle triangle. Further work on various right-angle triangles enhanced the novice teacher's understanding of trig ratios and resulted in a significantly better instruction of these concepts to their students. It should be noted that the teacher coach was not only available to work with the novice teacher in developing their understanding of trigonometry, but was also extremely appreciative of the novice teacher's willingness to acknowledge their lack of understanding of this challenging concept in mathematics. Moreover, the novice teacher knew prior to seeking assistance from the teacher coach that such an admission of ignorance would be welcomed by the teacher coach, as the teacher had been informed on numerous instances preceding this experience that teachers at the Calgary Girls' School are expected to continually develop their professional practice, regardless of the number of years of teaching experience they possessed.

Conclusion and Future Directions

Experiencing professional development in our school has certainly shaped the teachers we have become. Ultimately, we believe we have benefited from some of the most effective, long term, revisited and authentic professional development a teacher could ask for. We owe a huge thanks to Dr. Sharon Friesen and the Galileo Educational Network for their support and guidance throughout our journey as developing teachers. As well, we need to identify that the philosophy

and research our school was built upon have played a significant role in creating the community of trust and collaboration you find among all staff within the school. It is through these collaborative spaces that we have learned from both each other and the many mentors who have been invited into our school.

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